

and Heath House, and about 550 yards south-west of the first hole; and still later in that month, on the 19th, a third subsidence made its appearance, this time about 100 yards to the south-east of the first subsidence, and nearer to All Saints' Church.

The Astronomer-Royal and other inhabitants of the district being anxious to know how far other subsidences were probable, asked the Metropolitan Board of Works, who have jurisdiction over the Heath, and who had fenced in the sinkings, to investigate their cause. This however they declined to do, though giving to the Astronomer-Royal permission to do so; this authority he handed over to a newly-formed society, called the Lewisham and Blackheath Scientific Association, who formed a committee of investigation, including members of the West Kent Natural History Society, for which end subscriptions are now being sought, and operations will shortly be commenced, as announced in our columns.

The surface of the chalk is estimated by one member of the committee, Mr. T. V. Holmes, as probably occurring at about 100 feet from the surface at or about the Ordnance datum line. The investigations so far made show the third sinking to consist of an oval vertical shaft 7 feet 8 inches diameter by 6 feet 9 inches, with a depth of 18 feet, opening into a cavity extending in both directions, and partly choked with fallen earth, giving a total diameter, as far as examined, of 14 feet. The upper part of the shaft is described by Mr. Holmes as consisting of sand and clay resting on sand, overlying pebbles, in which the cavity below is formed. The material carefully removed from the bottom of the pit is found by Mr. H. W. Jackson to be of the same material as the upper beds of the shaft, proving the sinking due to removal of material from below. The first sinking is filled up and cannot be investigated; the second is not fully examined for want of funds, but is wholly in gravel, and also extends underground in two directions.

Various theories have been suggested by different observers to account for their origin, some considering them artificial, Admiral Hamilton that they are caused by the abstraction of water caused by the main-drainage works, which tapped powerful springs in the Lower Woolwich Road; others connect their appearance with removal of chalk, and water in the chalk, by the Kent Waterworks, who lift daily about nine million gallons a day from their wells in the neighbourhood, whilst others connect them with excessive rainfalls, the first subsidence having taken place after the great floods in the Ravensbourne, caused by the rain of the night of the 11th and morning of the 12th of April, 1878.

The height of the chalk water-line (*Journal, Society of Arts, 1877*) at Woolwich Dockyard well is about 15 feet below the Ordnance datum line before pumping, at the Kent Waterworks, Plumstead, 1 foot 4 inches below, but at the Kent Waterworks wells at Deptford it is pumped down to nearly 70 feet below, rising 50 feet after pumping, or about 20 feet below Ordnance datum. The surface of the chalk at Bromley, at the Shortlands pumping-station, has risen to 70 feet above the datum, the water rising after pumping to 122 feet above it. This district is on the south side of a synclinal axis ranging east-north-east through Eltham, described by Mr. Whitaker, which throws in a trough of London clay, that cuts off this supply, from the chalk water entering at the Greenwich Park escarpment.

The water-level under Blackheath is at, or about, Ordnance datum, trending south towards the London clay synclinal, corresponding, under the site of the subsidences, to the surface of the chalk beneath the Thanet sands, and if there is no great quantity of chalk above the water-level it appears improbable that the subsidences are due to pipes descending vertically into the chalk, but it is quite possible that the drainage works, removing the waters held by the pebble beds above,

disturbed their stability, and caused their subsidence. On the other hand it is not impossible that drift levels may have been driven into the chalk from the ancient chalk-pits a mile distant, ceasing when they reached the outcrop of the chalk against the Thanet sand, and which is immediately under the site of the subsidences.

C. E. DE RANCE

#### MERCADIER'S RESEARCHES ON THE PHOTOPHONE

A N elegant series of researches in photophony have lately been published by M. E. Mercadier of Paris, who has very carefully examined the phenomenon discovered by Graham Bell and Sumner Tainter, that an intermittent beam of light may generate a musical tone when it falls upon a thin disk. By way of distinguishing this phenomenon and its applications from the phenomenon of sensibility to light exhibited by annealed selenium, which constitutes the essential principle of the articulating photophone, M. Mercadier adopts the name of *radiophony* for the subject of his research: a name which appears moreover to have the advantage of not assuming *a priori* what kind of radiations, luminous, calorific, or actinic, are concerned in the production of the phenomenon. It is agreed by all who have experimented in this direction that the pitch of the note emitted by the disk corresponds precisely with the frequency of the intermittent flashes of light: but it has been disputed whether the effect is due to light or to heat. Prof. Bell found that the beam filtered through alum water to absorb the calorific ultra-red rays produced tones; and that even when a disk of thin ebonite rubber was interposed, the beam robbed of both heat-rays and light-rays could still generate tones. On the other hand, from the list of substances given by the original discoverers, it was evident that since dark and opaque substances with dull surfaces, and those which, like zinc and antimony, have high coefficients of thermal expansion, produce, *ceteris paribus*, the best results, the effects must probably arise from heating effects due to absorption of radiations of some kind and their degradation into heat of low temperature.

M. Mercadier has summarised his results in an article in the *Comptes rendus*, from which the substance of this article is translated freely. The chief conclusions are as follows:—

I. *Radiophony does not appear to be an effect due to the vibration of the receiving disk vibrating transversely in one mass as in an ordinary vibrating elastic plate.*—This conclusion appears to be justified by the following observations: that, given a thin plate of any kind, under the conditions necessary for the production of the phenomenon, it produces equally well tones of all different degrees of pitch from the lowest audible up to the highest that can be generated experimentally by optical intermissions, and which in M. Mercadier's apparatus attained to a frequency of 700 vibrations per second. Moreover it was found that these changes of pitch were accomplished without any defect in the continuity of the phenomenon; which would seem to indicate that it was not necessary for the plate to vibrate in any particular nodal or partial mode. Also the receiving disk will produce *chords* equally well in all possible tones from the highest to the lowest, the chord being complete no matter whether the fundamental pitch be raised or lowered by altering the speed of the rotating apparatus by which the intermissions are produced. M. Mercadier's apparatus consisted of a glass wheel carrying on its surface a paper disk pierced with four series of holes, numbering respectively 40, 50, 60, and 80. Through any one of these series of holes a small pencil of rays could be passed, and, by raising or depressing the axis of rotation of the wheel, could be sent successively through each of the four, thus

producing, at any given rate of rotation, the separate tones of a common chord in succession : or by interposing a cylindrical lens to distribute the rays in a linear beam to the four series at once, the united tones of the chord could be produced simultaneously.

Further it was found that the thickness and the breadth of the receiving-disk makes no difference within certain limits in the loudness or quality of the resulting tone. And in the case of transparent substances such as mica and glass these limits may be wide : in the case of glass the loudness was the same with a disk of half a millimetre as with one of three centimetres thickness. In consequence rare substances may be used in disks as small as one square centimetre in area. Cracked or split disks of glass, copper, and aluminium produce sensibly the same effects as if they were whole.

*II. The molecular structure and state of aggregation of the receiving disk appear to exercise no important influence upon the nature of the tones emitted.*—Disks of similar thickness and surface emit sounds of the same pitch no matter of what material they be. Although there may be slight specific differences between the actual modes of production of the phenomenon from very thin disks of different materials, these differences are reduced to a vanishing quantity by rendering the receptive surface alike, as for example by covering them all alike with a film of lampblack. Moreover the effect produced by ordinary radiations is, *ceteris paribus*, the same practically for transparent substances as widely differing from one another as glass, mica, selenite, Iceland-spar, and quartz, whether cut parallel or perpendicular to the optic axis, and is the same in polarised light as in ordinary light.

*III. The radiophonic sounds result from a direct action of radiations upon the receiving substances.*—This proposition appears to be established by the following facts :—  
1. That the loudness of the sounds is directly proportional to the quantity of rays that fall upon the disk. 2. That by using a polarised beam and taking as a receiving-disk a thin slice of some substance which can itself polarise or analyse light, such as a slice of tourmaline, the resulting sounds exhibit variations of loudness corresponding to those of the rays themselves, when either polariser or analyser is turned ; and the sound is loudest when the light transmitted by the analysing disk is a minimum.

*IV. The phenomenon appears to be chiefly due to an action on the surface of the receiver.*—The loudness of the emitted sound depends very greatly upon the nature of the surface. Everything that tends to diminish the reflecting power, and increase the absorbing power of the surface, assists the production of the phenomenon. Surfaces that are rough-ground or tarnished with a film of oxidation are therefore preferable. It is also advantageous to cover the receiving surface with black pulverulent deposits, bitumen black, platinum black, or best of all with lampblack ; but the increase of sensitiveness under this treatment is only considerable in the case of very thin disks, as for instance from '1 to '2 of a millimetre. Very sensitive radiophonic receivers may be thus made with extremely thin disks of zinc, glass, or mica smoked at the surface. It may here be noted amongst M. Mercadier's results that for opaque disks, the thinner they are the louder is the sound, and that excellent results are given by metallic foil—copper, aluminium, platinum, and especially zinc—of but '05 millim thickness. The employment of such sensitive receivers has enabled M. Mercadier to arrive at several other important conclusions.

*V. Radiophonic effects are relatively very intense.*—They can be produced not merely with sunlight or electric light, but with the lime-light, and also with gas-light, and even with petroleum flames, and with a spiral of platinum wire heated in the Bunsen-flame.

*VI. Radiophonic effects appear to be produced principally by radiations of great wave-length, or those commonly*

*regarded as calorific.*—In order to satisfy himself on this point M. Mercadier had recourse to the spectrum direct, without attempting to employ cells of absorbant material such as alum solution or iodine in dissolved bisulphide of carbon as ray-filters. A brilliant beam of light was produced by means of a battery of fifty Bunsen cells, and with this, by means of ordinary lenses and a prism of glass a spectrum was produced, the various regions of which could be explored with one of the sensitive receiving-disks mentioned above. The maximum effect was found to be produced by the red rays and by the invisible ultra-red rays. From yellow up to violet, and beyond, no perceptible results were obtained. The experiment was tried several times with receivers of smoked glass, platinised platinum, and plain bare zinc. The greatest effect appeared to be yielded at the limit of the visible red rays. The rays which affect the electric conductivity of selenium in the photophone are, as Prof. W. G. Adams has shown, not the red rays, but rays from the yellow and green-yellow regions of the spectrum. This fact alone would justify the distinction drawn between the phenomena of radiophony and those of the selenium photophone, though probably these are only two of several ways of arriving at a solution of the problem of the transmission of sonorous vibrations by radiation. Theoretically a telephone with a blackened disk inclosed in a high vacuum and connected with an external telephone should serve as a receiver ; and the writer of these lines has already attempted to devise a thermo-electric receiver for reproducing sounds from invisible calorific rays.

S. P. T.

#### THE JOHN DUNCAN FUND

THE following subscriptions to this fund have been received during the past week :—

	£ s. d.	£ s. d.
Amount previously announced ...	48 6 0	Major Deedes ...
Charles F. Tomes, F.R.S. ...	1 0 0	Anon. ...
J. S. ...	2 0 0	Sir J. Fayrer ...
Dr. Vacher ...	1 1 0	T. C. Kent ...
R. R. Glover ...	1 1 0	Lawson Tait ...
Thomas Walker ...	5 0 0	Heinrich Simon ...
M. M. Pattison Muir	1 1 0	
		65 2 3

#### THE TIME OF DAY IN PARIS

THE importance of precise and uniform time throughout Paris becoming ever and continually more appreciated, the Municipality have taken the matter in hand, and have established a system of what they call "horary centres." These horary centres really consist of standard clocks, erected in different places, and controlled by electricity from the Paris Observatory. Moreover each standard clock is furnished with additional electrical work of its own, which enables it to send out an hourly current and control other clocks in its neighbourhood, placed in circuit with it. The advantage of this arrangement over any system of electrical dials is apparent, for with the latter any mischance or practical joke with the wires would cause the whole city to be misled or completely deprived of time. The problem, as put by Leverrier, and as it has been practically solved by M. Breguet, was this :—To keep correct the hour given by various regulators distributed in the city by means of an electric current sent from the Observatory. If the current, in consequence of any accident, fails, the regulators continue to work, with a very slight advance, without the electric correction. The wires have their centre at the Observatory, where there is an astronomical regulator on the first floor. This instrument is maintained at the exact time indicated by the astronomical observations,